

# Optimization of the Recommended Time for Rectal Temperature Measurement in Children: An Observational Study

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## Abstract

**Background:** This study aimed to determine the optimum time required to measure rectal temperature in children with mercury-in-glass thermometers.

**Methods:** This cross-sectional observational study involved a random sample of pediatric patients  $\leq 5$  years of age. Body temperature was measured for 3 - 5 minutes using standard mercury-in-glass rectal thermometers. Outcomes were rectal body temperatures at 1, 2, and 3 minutes until reaching a stable rectal temperature, and the final rectal temperature. **Results:** This study recruited 120 children. Mean time to reach a stable rectal temperature was 1.8 minutes (range: 30 seconds to five minutes). 90% of pediatric patients' temperature came out within  $\pm 0.1^{\circ}\text{C}$  of the final temperature at two minutes. There was no correlation between the time taken to reach a stable rectal temperature and age, body weight, gender, or the final temperature. **Conclusion:** Mercury-in-glass thermometers can be used to obtain accurate rectal temperature measurements at two minutes in routine pediatric practice.

## Keywords

Fever, Mercury Thermometer, Pediatrics, Rectal Temperature

## 1. Introduction

Fever, defined as an elevation of the regulated set-point temperature by pyrogens, is frequently encountered in pediatrics [1]-[6]. Optimum fever control requires accurate temperature measurement, especially for critically ill patients [7]. Misdiagnosis of fever can result in improper treatment and poor patient out-

comes [8]. The objective diagnosis of fever in children is based on the measurement of body temperature at a peripheral site with an accurate thermometer [6] [9]. However, there is a debate on the best approach for temperature measurement and the most appropriate thermometer [10] [11].

The commonly used tools for measuring body temperature in a hospital are glass mercury thermometers, infrared thermometers and chemical point thermometers [12]. Although glass thermometer has decreased the use in pediatric patients currently [13], it is still widely applied to those patients who are suspected to get high temperature because of its accurate temperature measurement and low cost. Although some are replaced by electronic and infrared thermometers in clinic, glass thermometer is still widely used in homes [14]. The survey researching on the use of thermometer in 12 medical institutions of China showed that the use rate of mercury thermometer was 100% in medical institutions [15]. In China, most pediatrics currently use glass thermometers to measure body temperature [16].

When measuring a patient's body temperature, the aim is to determine the core body temperature, defined as the temperature of the core tissues of the body. The pulmonary artery catheter is the gold standard method for measuring core body temperature; however this approach is invasive and is only applicable in some settings. Alternatively, core body temperature can be measured noninvasively using oral thermometry, axillary thermometry, tympanic membrane thermometry, cutaneous infrared thermometry, or rectal thermometry [10].

Rectal thermometry is the gold standard minimally invasive method for measuring core body temperature in routine pediatric practice [17]. In pediatrics, the measurement of body temperature can be challenging, since it requires a specific time during which the patient must be inactive; and in the case of rectal thermometry, it can cause some discomfort. By minimizing the time taken to gain an accurate temperature reading, these issues may be effectively addressed. Chinese guidelines stipulate that a rectal temperature measurement should take three minutes [18] [19] [20], but some evidence suggests that this time can be reduced [21] [22] [23]. The objective of this study was to determine the optimum time required to measure rectal temperature in children with mercury-in-glass thermometers.

## 2. Methods

### 2.1. Study Subjects

This was a cross-sectional observational study involving a random sample simply of patients  $\leq 5$  years of age who attended the pediatric out-patient or emergency department of a third-grade a hospital from January 2015 to July 2015. Patients who were unwilling to use a rectal thermometer or children with diarrhea were excluded. This study was approved by the Ethics Committee of XiangYa Nursing School of Central South University. Written informed consent was obtained from the children's parents or guardians.

## 2.2. Procedures

Glass mercury thermometers that had been manufactured in a single batch (Shanghai Hua Chen Medical Instrument Co. Ltd.) were used in this study. The thermometers were calibrated by immersing them in a 40°C water bath for three minutes, and those that were accurate to  $\pm 0.1^\circ\text{C}$  were selected. During the investigation, all temperature measurements were carried out by a single physician. Before each measurement, the thermometers were dipped in paraffin oil for lubrication, and the mercury was set below 35°C. Timing was performed using watches that had been manufactured in a single batch.

All rectal temperature measurements were performed between 18:00 and 22:00. In order to protect the privacy of children, each rectal temperature measurement was performed in a separate room in the presence of the parents/guardians. The thermometer was inserted to a depth of 1.25 cm for infants, 2.5 cm for pre-school-aged children, and 2 - 3 cm for school-aged children. The physician held the thermometer and recorded the temperature every 30 seconds until the rectal temperature stabilized, defined as three consecutive unchanged readings.

Outcomes were rectal temperatures at 1, 2, and 3 minutes, time taken to reach a stable rectal temperature, and the final stable rectal temperature

## 2.3. Statistical Analysis

Data were analyzed using SPSS 17.0. Results are presented as means  $\pm$  standard deviation (SD). Student's *t*-test was used to compare thermometer readings at 1, 2, and 3 minutes. A frequency distribution was constructed to depict the times at which rectal temperature stabilized. Spearman's rank correlation analysis or non-parametric test was used for correlation analyses of rectal temperature measurements.

## 3. Results

This study included 120 children, of these, 82 were boys and 38 were girls. Patients had a mean age of 19.32 (19.32  $\pm$  18.80) months (range, 1 month-5 years). Mean body weight was 11.30  $\pm$  5.050 kg (range, 4 - 36 kg). Mean final rectal temperature was 38.4°C (range, 36.5°C - 40.3°C); 48 children were considered to have a normal body temperature and 72 children were diagnosed with fever [24] [25]. Mean time to reach a stable rectal temperature was 1.8 minutes (range 30 seconds to 5 minutes). 25.8% of cases showed rectal temperature was stable at 1 minute, in 78.3% of cases rectal temperature was stable at 2 minutes, and in 95.0% of cases rectal temperature was stable at 3 minutes (Table 1).

There were statistically significant differences in mean thermometer readings at 1, 2, and 3 minutes. The difference in mean thermometer readings at 3 minutes and 1 minute was 0.16°C, and at 3 minutes and 2 minutes was 0.04°C; the latter was within the allowable  $\pm 0.1^\circ\text{C}$  error for these thermometers (Table 2).

In 45% of cases, the readings were within  $\pm 0.1^\circ\text{C}$  of the final temperature at

one minute; in 90% of cases, the readings were within  $\pm 0.1^{\circ}\text{C}$  of the final temperature at two minutes; and in 97.5% of cases, the readings were within  $\pm 0.1^{\circ}\text{C}$  of the final temperature at three minutes (**Table 3**).

There was no correlation between time taken for rectal temperature to stabilize and age, body weight, gender, or final rectal body temperature (**Table 4**).

**Table 1.** Frequency distribution of time to reach a stable temperature.

Time (minutes)	Frequency	Percentage (%)	Cumulative Percentage (%)
0.5	3	2.5	2.5
1.0	28	23.3	25.8
1.5	35	29.2	55.0
2.0	28	23.3	78.3
2.5	10	8.3	86.7
3.0	10	8.3	95.0
3.5	3	2.5	97.5
4.0	1	0.8	98.3
5.0	2	1.7	100.0
Total	120	100.0	

**Table 2.** Comparison of mean thermometer readings at 1, 2 and 3 minutes.

Time (I)	Time (J)	Mean $^{\circ}\text{C}$ (I)	Mean $^{\circ}\text{C}$ (J)	Difference $^{\circ}\text{C}$ (I-J)	Standard deviation	tvalue	P value
1 min	2 min	38.20	38.33	-0.13	0.14	-9.741	<0.0001
	3 min		38.37	-0.16	0.13	-13.866	<0.0001
2 min	3 min	38.33	38.37	-0.04	0.10	-3.949	<0.0001

**Table 3.** Frequency distribution of the difference between the final temperature recorded and readings at 1 - 5 minutes.

Difference ( $^{\circ}\text{C}$ )	Frequency	Percentage (%)	Cumulative percentage (%)
1 minute			
0	31	25.8	25.8
0.1	23	19.2	45.0
0.2	31	25.8	70.8
0.3	23	19.2	90.0
0.4	7	5.8	95.8
0.5	3	2.5	98.3
0.6	2	1.7	100.0
Total	120	100.0	

## Continued

2 minutes			
0	94	78.3	78.3
0.1	14	11.7	90.0
0.2	7	5.8	95.8
0.3	3	2.5	98.3
0.4	1	0.8	99.2
0.5	1	0.8	100.0
Total	120	100.0	
3 minutes			
0	0	31	25.8
0.1	0.1	23	19.2
0.2	0.2	31	25.8
0.3	0.3	23	19.2
0.4	0.4	7	5.8
0.5	0.5	3	2.5
0.6	0.6	2	1.7
Total	120	100.0	
4 minutes			
0	94	78.3	78.3
0.1	14	11.7	90.0
0.2	7	5.8	95.8
0.3	3	2.5	98.3
0.4	1	0.8	99.2
0.5	1	0.8	100.0
Total	120	100.0	
5 minutes			
0	114	95.0	95.0
0.1	3	2.5	97.5
0.2	2	1.7	99.2
0.4	1	0.8	100.0
Total	120	100.0	

**Table 4.** Analyse for related factors of time taken to measuring rectal temperature.

	time taken to measuring rectal temperature		
	Age	Weight	rectal temperature
correlation coefficient	-0.083	-0.071	-0.080
<i>P</i> value	0.368	0.444	0.383

## 4. Discussion

The current study showed that a stable rectal temperature can be obtained using mercury-in-glass thermometers in pediatric patients within 1.8 minutes. In 78.3% of cases, a stable rectal temperature was obtained at two minutes. In 90% of cases, there was no significant difference (assuming an allowable error of  $\pm 0.1^{\circ}\text{C}$ ) between temperature readings at two and three minutes. These data suggested that accurate rectal temperature measurements using a mercury-in-glass thermometer could be obtained within two minutes for pediatric patients. These findings were unaffected by the demographic characteristics and final rectal temperature readings of patients. Therefore, rectal temperature measurements using mercury-in-glass thermometers might be appropriate in pediatric practice, where axillary temperature measurement is unavailable or a rapid estimate of body temperature is required.

Rectal temperature has been widely viewed as the gold standard for routine measurement of core body temperature in children. This site is not influenced by ambient temperature, and its use is not limited by age [10]. Mercury-in-glass thermometers are economical, measure temperature accurately to  $\pm 0.1^{\circ}\text{C}$  [26], are easy to disinfect, and continue to be widely used in clinical practice [27]. Current guidelines recommend three minutes for body temperature readings obtained with mercury-in-glass thermometers to stabilize [19] [20] [28] [29]. However, one study showed that mercury-in-glass thermometers in  $36^{\circ}\text{C}$  -  $42^{\circ}\text{C}$  water are able to provide a stable reading in less than a minute [21].

In the present study, we observed the rise of the mercury column during rectal temperature measurement, and found an initial rapid rise in the mercury column, followed by a slow increase. In 78.3% of cases, a stable rectal temperature was obtained at two minutes. These data were in accordance with the studies conducted by Chaturvedi *et al.* [28] and Nichols *et al.* [30], in which stable rectal temperatures were recorded using clinical thermometers in less than two minutes in 75% of pediatric patients and 74% of adult patients respectively. Other studies recorded stable rectal temperatures in pediatric patients in  $<1.5$  minutes [21] [22] [23] [31]. These disparate findings may be explained by the different research methods. In our study thermometer readings were recorded by one observer every 30 seconds, and a stable rectal temperature was defined as three unchanged consecutive readings [32] with an allowable error of  $\pm 0.1^{\circ}\text{C}$ . Other studies used several observers and one minute intervals.

Our findings revealed that rectal temperature readings were frequently within  $\pm 0.1^{\circ}\text{C}$  of the final temperature at two minutes. This suggested that although the mercury column continued to move, the distance was small enough to be ignored. Nichols *et al.* [30] defined  $0.2^{\circ}\text{F}$  below the maximum body temperature as the optimum body temperature for adult temperature and the optimum placement time as the time for 90% of the thermometer readings to reach the optimum body temperature. They found that 90% of thermometers reached optimal readings at two minutes, and considered two minutes the optimal time for

measuring rectal temperature in their patient population. Other studies [33] confirmed that rectal temperature measurement could be obtained in 1 - 2 minutes, and the present study demonstrated that two minutes was sufficient to obtain an accurate rectal temperature reading in children.

The present study found there was no correlation between the time taken to reach a stable rectal temperature and age, body weight, gender, or final rectal temperature. In contrast, Perera *et al.* [32] found that axillary temperature measurement time in children was related to age, body mass index, and final axillary temperature. These findings suggested that the time required for an accurate rectal temperature measurement was short, and that rectal temperature measurement was not influenced by patient demographic factors.

## 5. Conclusion

In conclusion, the findings from the present study suggested that mercury-in-glass thermometers could be used to obtain accurate rectal temperature measurements within two minutes in routine pediatric practice.

## Limitation

Due to the limitation of time and resources of manpower, this study still has some deficiencies, which are summarized as follows: The sample size of this study is only 120 cases, and there is a lack of relevant quantitative significance proof. In the future, the sample size will be expanded to improve this defect. The subjects included in the present study were all children under 5 years old, not involved in children above 5 years old, its aims to ensure the accuracy of the research results, in this study, glass anal thermometer was used to measure the body temperature of children, and it was difficult for children over 5 years old to accept the anal thermometer method, which would affect the progress of the study and the accuracy of the results.

## Fund Project

Rating for maternal and infant nursing staff [(2016)33].

## Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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